Optimizing regeneration and desulfurization processes reduces fuel penalty

OAAT ACCOMPLISHMENTS

Fuel Sulfur Effects on a NO_x Adsorber

Challenge

A NO_x adsorber catalyst is a flow-through emissions control device that can lower nitrogen oxides (NO_x), hydrocarbons (HC), and carbon monoxide (CO) emissions from engine exhaust. Fuel sulfur can contaminate the catalyst and inhibit effective reduction of NO_x to molecular nitrogen. In order to be used for many repetitive cycles over a vehicle's lifetime, the NO_x adsorber periodically must undergo processes to clear the NO_x (regeneration) and sulfur (desulfurization). Since both processes require the injection of extra fuel, a fuel penalty is incurred.

Testing of NO_x adsorber catalyst.

Technology Description

A 1.9L compression-ignition, direct-injection (CIDI) engine with common rail injection was used to evaluate the performance of a NO_x adsorber. The duration and air-to-fuel ratio of the fuel-rich exhaust used to reduce NO_x and regenerate the catalyst were optimized by adjusting engine operating conditions, including exhaust gas recirculation (EGR) level, throttling, main injection start, post-injection start, and post-injection quantity. The performance of previously tested catalysts was remapped with the newly optimized NO_x regeneration strategy over the operating temperature range of 300-450° C. An optimal desulfurization process was developed by manipulation of the same operating conditions, but at 700° C and a fixed air-to-fuel ratio of 0.9. It was applied to catalysts contaminated with sulfur such that their NO_x conversion rate had fallen by 25%. The ability of the NO_x adsorber to maintain performance over several cycles of sulfur contamination and desulfurization was tested with 3-ppm and 75-ppm sulfur fuel.

Accomplishments

The program developed an improved NO_x regeneration strategy that achieved greater than 90% NO_x conversion with a fresh catalyst. A desulfurization strategy lasting about six minutes was able to recover NO_x conversion efficiency to more than 80% for catalysts exposed to different fuel sulfur levels. Similar recovery of NO_x conversion efficiency was achieved when fresh catalysts were challenged with 3 and 75 ppm fuel sulfur and desulfurized over a number of cycles.

Benefits

- This program will help identify the optimal combinations of fuels, lubricants, diesel engines, and emission control systems to maintain high fuel economy while achieving ultra-low NO_x and PM emissions.
- Optimization of the regeneration and desulfurization processes will reduce the fuel penalty associated with those processes.

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Future Activities

Evaluations of NO_x adsorber technologies will continue under the Advanced Petroleum-Based Fuels-Diesel Emissions Control (APBF-DEC) Program. The Program will further investigate the regeneration and desulfurization processes using new engine control strategies.

Partners in Success

- Battelle Memorial Institute
- Engine Manufacturers Association
- FEV Engine Technologies, Inc.
- Manufacturers of Emission Control Association
- National Renewable Energy Laboratory
- Oak Ridge National Laboratory